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Wavelet based approach to signal activity detection and phase picking: Application to acoustic emission

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ABSTRACT

Locating the sources of elastic waves during rapid local stress relaxation in solids under load is a central element in acoustic emission non-destructive testing, seismology, etc. The location problem relies heavily on the accuracy of arrival time detection. To increase the reliability of real time signal detection and to ensure precise phase picking of transient waveforms of a low amplitude, we propose a novel Wavelet transform-based algorithm. Benefiting strongly from the neighboring concepts in the wavelet theory, the shortcomings of conventional amplitude threshold-based and Short Term Average/Long Term Average methods are addressed. The proposed method was validated in a variety of acoustic emission tests, demonstrating the excellent temporal localization of the picked phases even for the signals with very low signal-to-noise ratio.

1. Introduction

The correct "phase picking" or the determination of the onset time of a transient signal is of crucial importance in many fields of technology and science such as seismology, non-destructive acoustic emission (AE) testing, ultrasonics, etc. The generic similarity between the AE and seismic phenomenon is that both arise from rapid local stress relaxation events occurring in a solid body under local load. Thus, both deliver unique information regarding the incidence of local fracture or slip events with an unprecedented spatial/temporal resolution. The key point, which has determined the tremendous success of AE in the non-destructive testing practice, is its capability to locate the source of elastic waves in a way similar to that in seismology. For instance, the most commonly adopted procedure for source location in the AE practice is the so-called "triangulation" inherited from quantitative seismology. The temporal and spatial resolution of a vast majority of location methods are interconnected because the source location is computed using the time on the first arrival of the AE wave at each sensor in the antenna network. Thus, the accurate phase picking is central in the source location problem. This problem is however fundamentally complicated by background noise. Therefore, the aim of any signal detector and phase picker algorithm is to distinguish the signal from the noise and to identify the time of its arrival. Various data processing and onset picking algorithms have been proposed in the literature to minimize the localization error and determine the most likely location of the source in different geometries [1–3]. Providing comprehensive reviews to currently available signal detection algorithms Sharma et al. [4], and Küperkoch et al. [5] ended up with a conclusion that despite the vast amount of research in this field, the event picking algorithms had not yet fully come of age. While the AE field is dominated nowadays by the simplest amplitude threshold signal detector, the most widespread algorithm used in seismology for automatic phase detection is

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